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DETERMINATION OF TEST SPECTRUM FOR BLUE ANGELS A-4 FATIGUE INVESTIGATION

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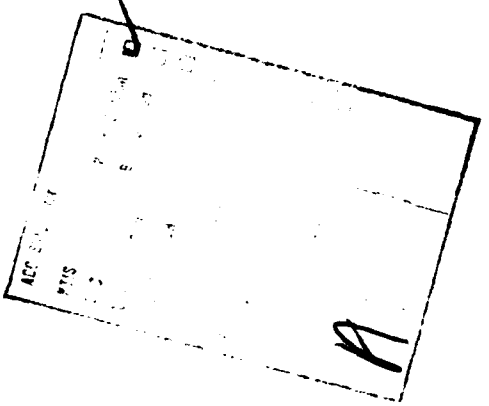

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In order to establish the structural fatigue lives of A-4 aircraft in service with the Blue Angels, a full-scale fatigue test will be performed on an A-4 airplane which will duplicate the loads and loading sequence experienced by the Blue Angel solo aircraft. The test program will assume that the solo airplane is always a solo airplane. That is, it is never rotated to the Diamond or Delta position. The test will be performed using a flight-by-flight loading spectrum based on actual flight data and composed of show, practice, and cross-country flights. The individual flight spectra and the overall

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mission spectrum are defined in this report.

SUMMARY

In order to establish the structural fatigue lives of A-4 aircraft in service with the Blue Angels, a full-scale fatigue test will be performed on an A-4 airplane which will duplicate the loads and loading sequence experienced by the Blue Angel solo aircraft. The test program will assume that the solo airplane is always a solo airplane. That is, it is never rotated to the Diamond or Delta position. The test will be performed using a flight-by-flight loading spectrum based on actual flight data and composed of show, practice, and cross-country flights. The individual flight spectra and the overall mission spectrum are defined in this report.

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BASIC INFORMATION

In order to establish the structural fatigue lives of A-4 airplanes in service with the Navy flight demonstration team known as the "Blue Angels", a full-scale structural fatigue test of an A-4 airplane will be performed. The test will duplicate the prime structural loads and loading sequence experienced by the Blue Angel Solo position airplane. The test program will assume that the solo airplane always remains a solo airplane and that it is flown every flight. That is, the solo airplane is never rotated to the Diamond or Delta position and it is never "down" for maintenance or other reasons.

The test spectrum, the determination of which is the objective of this report, will be a flight-by-flight loading spectrum composed of show, practice, and cross-country flights. It will be based on actual flight data gathered during the following programs:

I. Special flight loads monitoring survey - 26-27 February 1975
II. Flight Loads monitoring program - calendar year 1974
III. Normal load factor monitoring program - calendar year 1974

The special flight loads survey (I) involved monitoring airspeed, altitude, normal load factor, pitch rate, pitch attitude, roll rate, and roll attitude during three specially flown flights. For these flights the airplane flew, in known sequence, all the maneuvers performed by the solo airplane during a show. The flight parameters were monitored continuously during the flights and were recorded as oscillograph traces. The flight loads monitoring program (II) involved airspeed, altitude, and normal load factor during one complete flying season. The parameters were monitored continuously during each flight, from wheels-up to wheels-down and were recorded as oscillograph traces. The normal load factor monitoring program (III), commonly known as the counting accelerometer program, involved monitoring positive normal load factors at the 5, 6, 7, and 8 G levels for each Blue Angel airplane. The normal load factor was monitored continuously and the cumulative frequency of occurrence of each monitored G level was provided.

DEFINITION OF MANEUVERS

During the three flights of the special flight loads monitoring survey, the specific maneuvers listed below were executed:

Maneuver Name	Abbreviation	Number of Times Performed
Take-off roll	TOR	2
6 Climbing rolls	6CR	1
Knife edge	KE	8
Inverted pass	IVD	13
4 Point roll	4PR	9
3 Horizontal rolls	3HR	4
½ Cuban eight	½C8	6
8 Point roll	8PR	2
Blivot	BLV	4
Head-on-pass	HO	2
Spacer	SP	1
Tuck-away break	TAB	5
Clean roll-Immelman	CRI	1
Inverted-to-inverted	II	3

Of the parameters monitored during the maneuvers, the normal load factor (N_Z), pitch rate (ω_Y), and roll rate (ω_X) are of prime consideration in determining the aerodynamic loads imposed on the airplane structure. A point-by-point engineering review of the oscillograph traces found negligible fluctuations of the pitch rate. As such, the pitching acceleration and the loadings induced by this acceleration were considered to be zero. Therefore, in defining the maneuvers, attention was directed to the normal load factor (N_Z) and the rolling acceleration $\left(\dot{\omega}_X = \frac{d\omega_X}{dt}\right)$.

The parameters N_Z and $\dot{\omega}_X$ have been classified, for the purposes of this test program, as follows:

Normal Load Factor N_Z, G's	Rolling Acceleration $\dot{\omega}_X$, rad/sec. sq.
N_Z above 8.00 ≅ 8.5	$\dot{\omega}_X \leq 4.0$ will be ignored since this would produce a wing unbalance semi-span moment less than that equivalent to 0.25 G
7.00 → 7.99 ≅ 7.5	
6.00 → 6.99 ≅ 6.5	
5.00 → 5.99 ≅ 5.5	
4.00 → 4.99 ≅ 4.5	$\dot{\omega}_X$ below 9.0 ≡ 6.0
3.00 → 3.99 ≅ 3.5	$\dot{\omega}_X$ above 9.0 ≡ 12.0
1.75 → 2.99 ≅ 2.5	
0.26 → 1.74 ≅ 1.0	Due to test constraints any $\dot{\omega}_X$ indicated at N_Z = 1.0 will be performed during the test, at N_Z = 1.5
0.25 → -0.99 ≅ -0.5	
-1.00 → -1.99 ≅ -1.5	
-2.00 → -2.99 ≅ -2.5	$+\dot{\omega}_X \equiv$ left wing up - right wing down
N_Z below -3.00 ≅ -3.5	$-\dot{\omega}_X \equiv$ right wing up - left wing down

Note: $N_Z = \left({}^{a_z}/_{g}\right) + 1$ where a_z = normal acceleration, g = gravitational acceleration

In MIL-A-8861, "Airplane Strength and Rigidity Flight Loads," it is stated that the cockpit lateral control (and therefore the ailerons) shall be displaced to the maximum by application of the control force in not more than 0.1 seconds. With this as a guide, it is considered, for purposes of this program, that the peak loading due to rolling acceleration occurs 0.1 seconds after a rolling maneuver is initiated (e.g., 0.1 seconds after a departure of the roll rate trace from the zero position). Therefore, in order to calculate the airplane loading associated with a rolling maneuver, the value of the N_Z oscillograph trace was read and the slope of a line normal to the ω_X trace ($\dot{\omega}_X$) was determined, at the instant in time corresponding to the above defined point of peak loading. By using these N_Z and $\dot{\omega}_X$ values and the value of the N_Z trace at all other peaks and valleys, the specific maneuvers previously listed could be analyzed. A sample oscillograph trace of a maneuver, with N_Z and $\dot{\omega}_X$ readings, is shown in Figure 1.

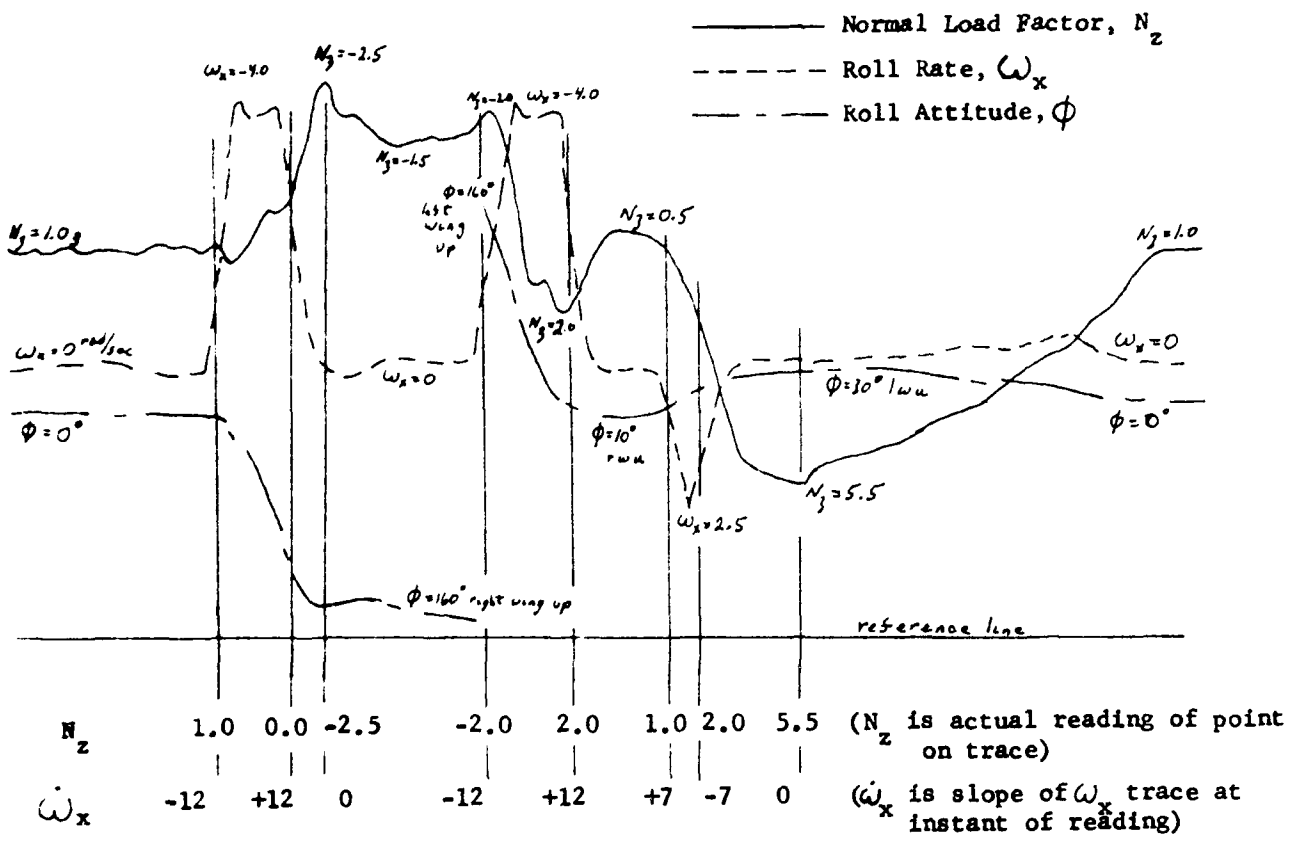

Figure 1. Sample Oscillograph Trace - Inverted Pass Maneuver

The sample trace of Figure 1 can be reproduced in tabular form in two ways as follows:

1. Using N_Z peaks and valleys and taking into consideration the loading due to $\dot{\omega}_X$:

Actual Values	Coded and Classified
$N_Z = 1.0, \dot{\omega}_X = 0$	1.0
$N_Z = 1.0, \dot{\omega}_X = -12$	1.5 - 12
$N_Z = 0.0, \dot{\omega}_X = +12$	-0.5 + 12
$N_Z = -2.5, \dot{\omega}_X = 0$	-2.5
$N_Z = -2.0, \dot{\omega}_X = -12$	-2.0 - 12
$N_Z = 2.0, \dot{\omega}_X = +12$	2.0 + 12
$N_Z = 1.0, \dot{\omega}_X = +7$	1.5 + 6
$N_Z = 2.0, \dot{\omega}_X = -7$	2.0 - 6
$N_Z = 5.5, \dot{\omega}_X = 0$	5.5
$N_Z = 1.0, \dot{\omega}_X = 0$	1.0

2. Using the N_Z trace only and only reading peaks ("Peak Reading Method"):

1.0
-2.5
2.0
1.0
5.5
1.0

Reproducing each maneuver flown during the special flight loads survey in tabular form, using the methods shown in Figure 1, and performing an engineering comparison of like maneuvers, it was found that each type of maneuver indeed shows a general repeatability of the values and sequencing of the N_Z and $\dot{\omega}_X$ parameters. Therefore, except for some distinct fluctuations in peak N_Z values, each type of maneuver can be defined as a specific combination and sequencing of the N_Z and $\dot{\omega}_X$ parameters. The maneuvers are defined, using the classified parameters, in tabular form in Table I. Fluctuations in N_Z are incorporated by redefining a maneuver with different N_Z values where appropriate. The maneuvers have also been defined using the peak reading method. This type of definition is used in constructing load exceedance curves.

TABLE I

MANEUVER DEFINITION - N_Z AND $\dot{\omega}_X$

TOR	6CR	KE(1)	KE(2)	IVD	4PR	3HR(1)	3HR(2)	½C8(1)	½C8(2)
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2.5	5.5	3.5∓12	3.5∓12	-1.5∓12	4.5∓12	4.5-12	4.5-12	3.5	3.5
1.0	3.5-12	-1.5	-1.5	-2.5	-1.5∓12	-0.5	-0.5	1.5∓6	1.5∓6
3.5	-0.5	1.5∓12	1.5∓12	-1.5∓12	-1.5∓12	1.0	1.0	-0.5	-0.5
1.0	3.5+12	2.5	2.5	3.5	3.5∓12	-0.5	-0.5	1.5-12	1.5-12
	1.5∓6	1.5∓12	1.5∓12	1.5∓12	1.0	1.0	1.0	-0.5	-0.5
	3.5	5.5	7.5	5.5∓6	5.5∓6	3.5+12	3.5+12	3.5+12	3.5+12
	1.0	5.5∓6	5.5∓6	1.0	5.5∓6	1.0	1.0	4.5	6.5
		1.0	1.0		1.0	3.5∓12	3.5∓12	1.5∓12	1.5∓12
						4.5	7.5	6.5	7.5
						1.0	1.0	5.5∓6	5.5∓6
								1.0	1.0

By the peak reading method

TOR	6CR	KE(1)	KE(2)	IVD	4PR	3HR(1)	3HR(2)	½C8(1)	½C8(2)
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2.5	5.5	3.5	3.5	-2.5	4.5	4.5	4.5	3.5	3.5
1.0	-0.5	-1.5	-1.5	3.5	-1.5	-0.5	-0.5	-0.5	-0.5
3.5	3.5	2.5	2.5	1.0	3.5	1.0	1.0	1.0	1.0
1.0	1.0	1.0	1.0	5.5	1.0	-0.5	-0.5	-0.5	-0.5
	3.5	5.5	7.5	1.0	5.5	3.5	3.5	4.5	6.5
	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0
						4.5	7.5	6.5	7.5
						1.0	1.0	1.0	1.0

TABLE I (Cont'd)

½C8(3)	8PR	BLV	HO	SP	TAB(1)	TAB(2)	TAB(3)
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3.5	4.5∓12	3.5	1.5∓12	5.5∓6	4.5∓12	4.5∓12	4.5∓12
1.5∓6	-1.5∓12	-0.5	3.5	6.5	-0.5	-1.5	-0.5
-0.5	-1.5∓12	3.5	1.5∓6	5.5∓6	5.5	5.5	7.5
1.5-12	-1.5∓12	1.0	3.5	1.0	1.0	1.0	1.0
-0.5	-1.5∓12	3.5	1.5∓6				
3.5+12	-1.5∓12	1.0	1.0				
6.5	-1.5∓12	4.5∓12					
1.5∓12	3.5∓12	1.0					
8.5	1.0						
5.5∓6							
1.0							

By the peak reading method

½C8(3)	8PR	BLV	HO	SP	TAB(1)	TAB(2)	TAB(3)
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3.5	4.5	3.5	3.5	6.5	4.5	4.5	4.5
-0.5	-1.5	-0.5	1.0	1.0	-0.5	-1.5	-0.5
1.0	3.5	3.5	3.5		5.5	5.5	7.5
-0.5	1.0	1.0	1.0		1.0	1.0	1.0
6.5		3.5					
1.0		1.0					
8.5		4.5					
1.0		1.0					

TABLE I (Cont'd)

CRI	II(1)	II(2)	LDG*	BML**
1.0	1.0	1.0	1.0	1.0
3.5	1.5-12	1.5-12	Land	2.5
1.5∓6	2.5	2.5	1.0	1.0
3.5	1.5+12	1.5+12		2.5
1.0	-2.5	-1.5		1.0
	2.5	2.5		2.5
	-1.5∓12	-1.5∓12		1.0
	2.5	2.5		2.5
	1.5∓12	1.5∓12		1.0
	5.5	5.5		
	1.0	1.0		

By the peak reading method

CRI	II(1)	II(2)	LDG*	BML**
1.0	1.0	1.0	1.0	1.0
3.5	2.5	2.5	1.37	2.5
1.0	-2.5	-1.5	1.0	1.0
3.5	2.5	2.5		2.5
1.0	-1.5	-1.5		1.0
	2.5	2.5		2.5
	1.0	1.0		1.0
	5.5	5.5		2.5
	1.0	1.0		1.0

* LDG is the landing maneuver. The landing load is composed of air load, inertia, load, and landing gear load. The landing load in terms of wing root bending moment is equivalent to 1.37G.

** BML is between maneuver loading and is a constructed (as opposed to flight measured) maneuver.

DETERMINATION OF THE LOAD EXCEEDANCE CURVES

A sampling of the data measured in monitoring programs II and III is provided in Table II wherein the cumulative counts of N_Z exceedances for four load levels is listed. A totaling of this data for each specific airplane monitored is given in Table III. Summing the data in Table III by type of flight permits a comparison of the two monitoring programs as shown below:

Average Cumulative Counts* of N_Z Exceedances Per Solo Airplane Flight

	Program II				Program III		
N_Z	Show	Practice	Cross-Country	N_Z	Show	Practice	Cross-Country
8.5	0.04	0	0	8.5	0.04	0	0
7.5	0.92	0.21	0.03	7.5	0.72	0.18	0.03
6.5	4.00	1.33	0.61	6.5	4.10	1.24	0.61
5.5	8.98	5.64	1.81	5.5	8.78	5.58	1.77
t_o**	0.520	0.846	1.154	t_1**	0.844	1.191	1.639

* Average Cumulative Counts Per Flight = total cumulative counts ÷ total number of flights.

** t_o = total oscillograph hours ÷ total number of flights = average oscillograph flight hours per flight

t_1 = total log book hours ÷ total number of flights = average log book flight hours per flight

Oscillograph time is elapsed time from wheels up to wheels down. Log book time is, at the minimum, elapsed time from start of take-off roll to completion of landing roll and, at the maximum, elapsed time from start of take-off taxi to wheels chocked at completion of landing taxi. As such, for the same flight, log book time will always be greater than oscillograph time.

The information given in the above table is plotted in Figure 2. As can be seen from the table and the plot, there is excellent correlation between the two monitoring methods. Therefore, by using the proper relationship between oscillograph and log book flight time, the N_Z counts for one method can be calculated from the N_Z counts of the other method.

Table II

1974 Flight Logs of Specific Blue Angels Airplanes

Airplane Serial No, 155209

FLIGHT NUMBER	DATE	FLIGHT PURPOSE CODE	LOG BOOK HOURS	OSCILL HOURS	EXCEEDANCES OSCILLOGRAPH				COUNTER			
					5	6	7	8	5	6	7	8
1	4-24-74	Practice	1.3	0.87	16	4	1	0	11	2	0	0
2	4-25-74	"	1.3	0.92	9	3	0	0	11	3	0	0
3	4-30-74	"	1.0	0.83	0	0	0	0	0	0	0	0
4	5- 1-74	"	1.2	0.85	0	0	0	0	0	0	0	0
5	5- 2-74	"	1.0	0.62	1	0	0	0	0	0	0	0
6	5- 6-74	"	1.3	0.88	9	3	0	0	9	1	0	0
7	5- 6-74	Check Out	1.3	1.00	1	0	0	0	1	0	0	0
8	5- 7-74	Practice	1.3	0.93	0	0	0	0	0	0	0	0
9	5- 9-74	"	1.3	0.95	9	2	0	0	8	1	0	0
10	5-13-74	Show	0.8	0.43	10	3	0	0	10	3	1	0
11	5-14-74	Practice	1.4	1.08	5	0	0	0	3	0	0	0
12	5-18-74	Show	0.6	0.22	7	4	1	0	7	4	0	0
13	5-19-74	"	0.7	0.35	8	2	1	0	8	1	1	0
14	5-19-74	Cross Cty	2.0	1.75	0	0	0	0	0	0	0	0
15	5-24-74	Show	0.8	0.50	7	2	0	0	7	2	0	0
16	5-25-74	Cross Cty	2.0	0.42	9	4	0	0	8	4	0	0
17	5-27-74	Show	1.0	0.72	9	1	0	0	7	0	0	0
18	6- 3-74	"	1.2	0.83	9	4	0	0	10	4	0	0
19	6- 5-74	"	0.8	0.45	9	6	0	0	8	5	0	0
20	6- 6-74	"	0.8	0.47	9	5	1	0	9	5	1	0
21	6- 8-74	"	0.8	0.43	9	4	0	0	9	4	0	0
22	6- 9-74	"	0.8	0.48	6	3	0	0	6	5	0	0
23	6- 9-74	Cross Cty	1.5	1.30	0	0	0	0	0	0	0	0
24	6-12-74	Practice	1.2	1.17	8	3	0	0	8	3	1	0
25	6-12-74	"	1.0	0.68	4	0	0	0	4	0	0	0
26	6-15-74	Cross Cty	1.0	0.75	5	4	0	0	4	2	0	0
27	6-16-74	Show	0.8	0.57	9	2	0	0	6	1	0	0
28	6-16-74	Cross Cty	1.0	0.57	0	0	0	0	0	0	0	0
29	6-20-74	"	1.2	1.02	6	4	0	0	6	3	0	0
30	6-21-74	Show	0.8	0.40	6	1	0	0	6	1	0	0

Table II (Cont'd)

Airplane Serial No. 155209

FLIGHT NUMBER	DATE	FLIGHT PURPOSE CODE	LOG BOOK HOURS	OSCILL HOURS	EXCEEDANCES OSCILLOGRAPH 5	6	7	8	COUNTER 5	6	7	8
31	6-22-74	Show	0.8	0.48	8	2	0	0	7	1	0	0
32	6-23-74	Cross Cty	0.9	0.63	0	0	0	0	0	0	0	0
33	7-12-74	" "	3.7	1.33	0	0	0	0	0	0	0	0
34	7-12-74	" "		1.87								
35	7-13-74	Show	1.0	0.78	5	2	0	0	4	2	0	0
36	7-14-74	Show	1.0	0.83	5	2	1	0	4	2	1	0
37	7-15-74	Cross Cty	2.6	1.32	0	0	0	0	0	0	0	0
38	7-15-74	Cross Cty		.72								
39	7-18-74	Cross Cty	4.0	1.48	0	0	0	0	0	0	0	0
40	7-18-74	Cross Cty										
41	7-17-74	Check Out	0.5	0.28	8	0	0	0	7	0	0	0
42	7-19-74	Practice	1.0	0.62	7	1	0	0	7	1	0	0
43	7-20-74	Show	1.0	0.62	10	2	1	0	9	2	0	0
44	8-23-74	Practice	0.8	0.48	10	2	0	0	10	4	0	0
45	8-24-74	Show	0.8	0.43	7	1	0	0	8	3	0	0
46	8-24-74	Cross Cty	1.0	1.03	1	1	0	0	0	0	0	0
47	8-25-74	Show	1.3	0.42	8	1	0	0	8	2	1	0
48	8-25-74	Cross Cty	1.3	0.83	0	0	0	0	0	0	0	0
					259	81	6	0	253	73	6	0

Table II (Cont'd)

Airplane Serial No. 154179

FLIGHT NUMBER	DATE	FLIGHT PURPOSE CODE	LOG BOOK HOURS	OSCILL HOURS	EXCEEDANCES OSCILLOGRAPH				COUNTER			
					5	6	7	8	5	6	7	8
1	3-29-74	Practice	1.3	.45	6	0	0	0	4	0	0	0
2	3-29-74	Practice		.92								
3	4- 1-74	Practice	1.3	.82	6	0	0	0	6	0	0	0
4	4- 1-74	"	1.3	.82	3	0	0	0	3	0	0	0
5	4- 2-74	"	0.7	.38			NA		0	0	0	0
6	4- 9-74	"	1.4	.28			NA		9	0	0	0
7	4-9-74	"	1.0	.35			NA		9	0	0	0
8	4-10-74	"	1.3	.72	6	0	0	0	7	0	0	0
9	4-10-74	"	0.7	.23			NA		4	1	0	0
10	4-16-74	Show	0.8	.43	11	4	0	0	10	4	0	0
11	4-17-74	Practice	1.3	1.02	2	0	0	0	3	0	0	0
12	4-17-74	"	1.3	.63	0	0	0	0	0	0	0	0
13	4-18-74	"	1.3	.90	6	0	0	0	6	0	0	0
14	4-19-74	"	1.3	.93	7	0	0	0	9	1	0	0
15	4-25-74	"	1.3	.90			NA		13	2	0	0
16	4-29-74	"	1.3	1.02	8	0	0	0	9	1	0	0
17	4-30-74	"	1.0	.85	0	0	0	0	0	0	0	0
18	5- 2-74	"	1.0	.57	2	0	0	0	3	0	0	0
19	5- 1-74	"	1.3	1.02	0	0	0	0	0	0	0	0
20	5- 6-74	"	1.3	.80	7	0	0	0	7	0	0	0
21	5- 7-74	"	1.3	.88	10	2	1	0	9	2	1	0
22	5-19-74	Cross Cty	2.0	1.60	0	0	0	0	0	0	0	0
23	5-24-74	Show	0.8	.50	3	0	0	0	4	0	0	0
24	5-26-74	"	0.8	.43	10	2	0	0	10	3	0	0
25	5-27-74	"	1.0	.78	8	2	0	0	7	2	0	0
26	6- 2-74	Cross Cty	2.1	.88	7	0	0	0	8	0	0	0
27	5-30-74	Practice	1.2	.88	0	0	0	0	0	0	0	0
28	6- 3-74	Show	1.2	.82	6	3	0	0	5	3	0	0
29	6- 5-74	"	0.8	.50	12	5	0	0	12	5	0	0
30	6- 6-74	"	0.8	.50	9	2	0	0	12	2	0	0

Table II (Cont'd)

Airplane Serial No. 151749

FLIGHT NUMBER	DATE	FLIGHT PURPOSE CODE	LOG BOOK HOURS	OSCILL HOURS	EXCEEDANCES OSCILLOGRAPH 5	6	7	8	COUNTER 5	6	7	8
31	6- 8-74	Show	0.7	.28	6	2	0	0	3	0	0	0
32	6-12-74	Practice	1.0	.88	1	0	0	0	3	0	0	0
33	6-13-74	Check Out	0.5	.27	4	0	0	0	0	0	0	0
34	6-15-74	Cross Cty	1.0	.72	5	0	0	0	5	1	0	0
35	6-16-74	Show	0.8	.55	7	2	0	0	7	2	0	0
36	6-16-74	Cross Cty	1.0	.58	0	0	0	0	0	0	0	0
37	6-19-74	Practice	1.1	1.03	5	1	0	0	6	1	0	0
38	6-20-74	Cross Cty	1.2	1.32	5	1	0	0	5	1	0	0
39	6-21-74	Show	0.8	.57	6	1	0	0	6	1	0	0
40	6-22-74	"	0.8	.63	11	3	0	0	11	2	0	0
41	6-23-74	Cross Cty	0.9	.70	0	0	0	0	0	0	0	0
42	6-27-74	"	1.9	1.60	1	0	0	0	1	0	0	0
43	6-28-74	Show	0.8	.65	6	2	0	0	10	8	0	0
44	6-29-74	"	0.8	.33	10	4	0	0	0	0	0	0
45	6-30-74	Check Out	0.3	.15	1	0	0	0	1	0	0	0
46	6-30-74	Show	0.8	.52	9	3	0	0	8	3	0	0
47	6-30-74	Cross Cty	1.3	1.23	0	0	0	0	0	0	0	0
48	7- 4-74	Show	0.8	.40	10	5	1	0	9	5	1	0
49	7- 5-74	Cross Cty	1.5	1.03	2	0	0	0	2	0	0	0
50	7- 6-74	Show	0.9	.77	9	5	2	1	9	5	1	1
51	7- 7-74	"	1.0	.80	9	8	2	0	10	8	2	0
52	7- 7-74	Cross Cty	1.8	2.03	0	0	0	0	0	0	0	0
					236	57	6	1	230	60	5	1

Table II (Cont'd)

Airplane Serial No. 154177

FLIGHT NUMBER	DATE	FLIGHT PURPOSE CODE	LOG BOOK HOURS	OSCILL HOURS	EXCEEDANCES OSCILLOGRAPH 5	6	7	8	COUNTER 5	6	7	8
1	9-20-74	Practice	0.8	.53	10	7	1	0	10	6	0	0
2	9-21-74	Show	0.8	.47	9	7	2	0	11	8	2	0
3	9-22-74	"	0.8	.43	10	8	5	0	11	9	6	0
4	9-27-74	Practice	0.9	.57	13	8	3	0	13	7	3	0
5	9-28-74	Show	0.8	.47	13	6	3	0	13	6	1	0
6												
7	10- 1-74	Cross Cty	1.0	.30	0	0	0	0	0	0	0	0
8	10- 4-74	"	1.3	1.05	7	0	0	0	8	3	0	0
9	10- 4-74	Show	0.8	.47	9	5	0	0	11	7	1	0
10	10- 4-74	Cross Cty	0.6	.35	0	0	0	0	0	0	0	0
11	10- 5-74	Show	0.8	.43	10	8	2	0	11	9	2	0
12	10- 6-74	"	0.8	.45	12	6	2	0	11	5	2	0
13	10-11-74	"	0.8	.45	14	5	0	0	16	7	0	0
14	10-12-74	"	0.8	.47	11	4	0	0	11	2	0	0
15	10-12-74	Cross Cty	1.0	.67	3	1	1	0	3	1	1	0
16	10-13-74	Show	0.8	.43	10	5	2	0	11	5	2	0
17	10-18-74	Practice	0.8	.32	6	2	0	0	5	2	0	0
18	10-19-74	Show	0.8	.67	13	9	4	0	13	9	2	0
19	10-21-74	Cross Cty	5.5	2.10	0	0	0	0	0	0	0	0
20	10-24-74	"		1.63	0	0	0	0	0	0	0	0
21	10-31-74	"	1.2	.93	4	4	0	0	4	4	0	0
22	11-01-74	Practice	0.8	.48	10	6	1	0	10	6	1	0
23	11-02-74	Show	0.8	.45	11	6	3	0	11	6	2	0
24	11-03-74	"	0.8	.45	11	7	3	1	10	7	1	0
25	11-03-74	Cross Cty	1.0	.32	0	0	0	0	0	0	0	0
26	11-07-74	"	1.5	1.47			NC				NC	
27	11-08-74	Show	0.8	.5	11	8	2	0	10	8	1	1
28	11-09-74	Unknown	0.6	.28	0	0	0	0	0	0	0	0
29	11-09-74	Show	0.8	.48	10	8	5	0	9	9	3	0
30	11-09-74	Cross Cty	1.4	1.00	1	0	0	0	1	0	0	0
31	11-10-74	Show	0.8	.50	12	8	3	0	14	8	2	0
32	11-10-74	Cross Cty	0.9	.72	0	0	0	0	0	0	0	0
					220	128	42	1	227	134	32	1

TABLE III

Compilation of 1974 Flight Logs

AIRPLANE SERIAL NO.	FLIGHT PURPOSE CODE	NUMBER OF FLIGHTS	LOG BOOK HOURS	OSCILL HOURS	Exceedances: Oscillograph 5	Oscillograph 6	Oscillograph 7	Oscillograph 8	Counter 5	Counter 6	Counter 7	Counter 8
155029	Show (Total)	18	15.8	9.41	141	47	5	0	133	47	5	0
	Show (Ave)		.88	.52	7.8	2.6	.3	0	7.4	2.6	.3	0
	Practice (Total)	12	15.1	10.88	78	18	1	0	71	15	1	0
	Practice (Ave)		1.26	.91	6.5	1.5	.1	0	5.9	1.3	.1	0
	Cross Cty (Total)	12	22.2	15.02	21	13	0	0	18	9	0	0
	Cross Cty (Ave)		1.85	1.25	1.8	1.1	0	0	1.5	.8	0	0
154179	Show (Total)	17	14.4	9.46	142	53	5	1	133	53	4	1
	Show (Ave)		.85	.56	8.4	3.1	.3	.1	7.8	3.1	.2	.1
	Practice (Total)	17	20.9	15.14	69	3	1	0	75	5	1	0
	Practice (Ave)		1.23	.89	4.1	.2	.1	0	4.4	.3	.1	0
	Cross Cty (Total)	10	14.7	11.69	20	1	0	0	21	2	0	0
	Cross Cty (Ave)		1.47	1.17	2	.1	0	0	2.1	.2	0	0
154177	Show (Total)	15	12.0	7.12	166	100	36	1	173	105	27	1
	Show (Ave)		.8	.48	11.1	6.7	2.4	.1	11.5	7.0	1.8	.1
	Practice (Total)	4	3.3	1.9	39	23	5	0	38	21	4	0
	Practice (Ave)		.83	.48	9.8	5.8	1.3	0	9.5	5.3	1	0
	Cross Cty (Total)	9	13.9	9.1	15	5	1	0	16	8	1	0
	Cross Cty (Ave)		1.54	1.01	1.7	.6	.1	0	1.8	.9	.1	0

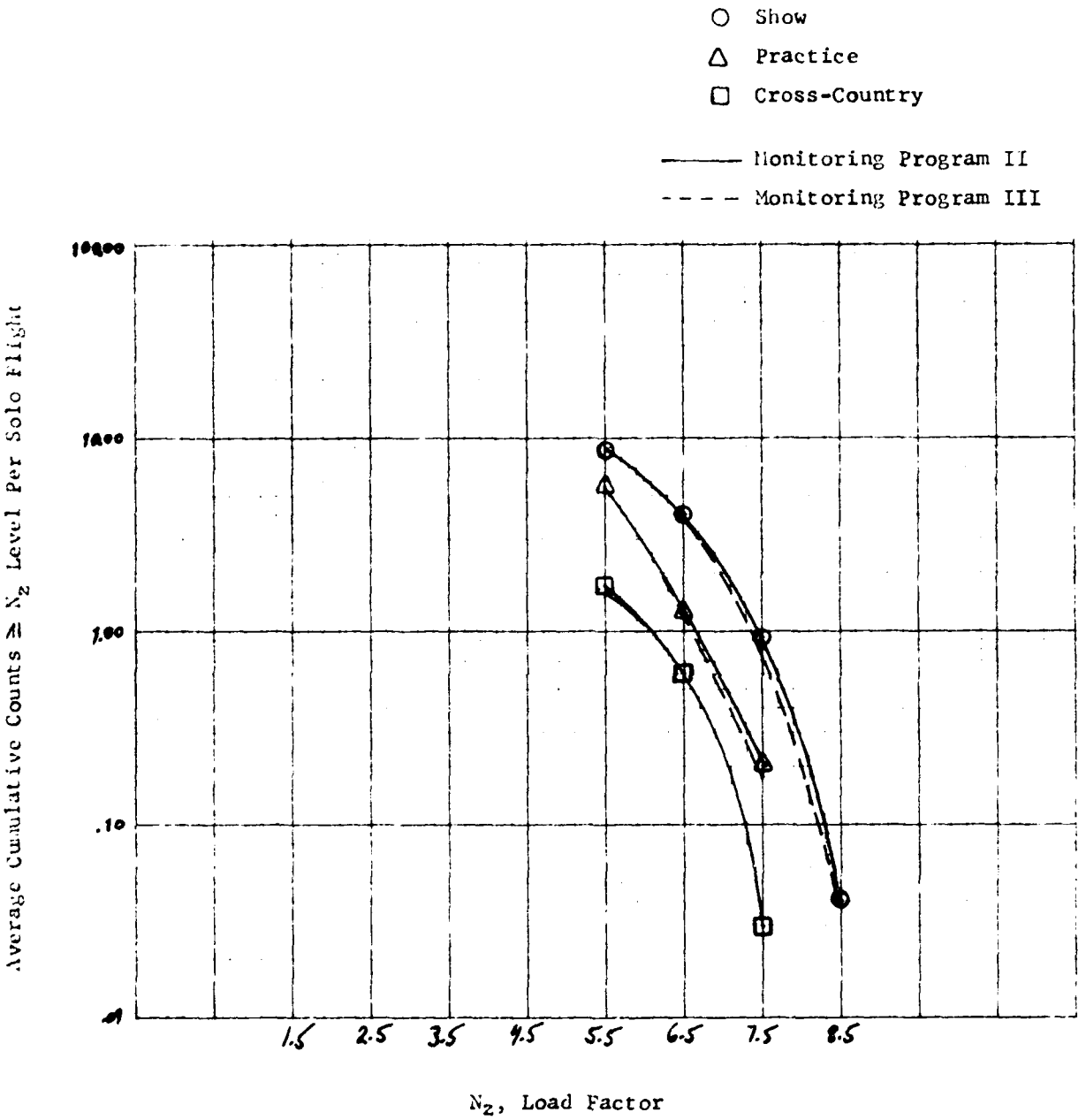

Figure 2. Load Exceedance Curves for Average N_z Counts

Reanalyzing the measured data by performing a regression analysis to determine the mean cumulative N_z counts produces the results listed below. The method of analysis is detailed in Appendix B of NADC Report 13920-2 dated 1 May 1975, "Statistical Review of Counting Accelerometer Data for Navy and Marine Fleet Aircraft from 1 Jan 1962 to 31 Dec 1974." The following information is plotted on Figure 3 to show comparability between the different types of flights and between the monitoring methods.

Mean Cumulative Counts/Average Flight

	Program II				Program III		
N_z	Solo Show	Solo Pract	Solo Cross Country	N_z	Solo Show	Solo Pract	Solo Cross Country
8.5	0.045	0	0	8.5	0.041	0.027	
7.5	0.847	0.177	0.011	7.5	0.757	0.257	Regression Analysis not Performed
6.5	3.685	1.166	0.338	6.5	4.003	1.334	
5.5	8.128	5.313	0.909	5.5	8.822	5.939	
4.5	16.565	15.440	1.930				
3.5	41.226	39.779	4.731				
2.5	86.194	89.605	13.679				
1.5	NA	NA	NA				
0.5	NA	NA	NA				
-0.5	13.923	12.605	2.354				
-1.5	4.409	3.803	0.726				
-2.5	0.990	0.473	0.097				
-3.5	0	0	0				
t_o	0.514	0.742	0.960	t_1	0.837	1.131	1.359

0.514 mean osc. show hours $\cong$ 0.837 Log Book show hours*

0.742 mean osc. practice hours $\cong$ 1.131 Log Book practice hours

0.960 mean osc. cross country hours $\cong$ 1.359 Log Book cross country hours

* Oscillograph time is elapsed time from wheels up to wheels down. Log Book time is, at the minimum, elapsed time from start of take-off roll to completion of landing roll.

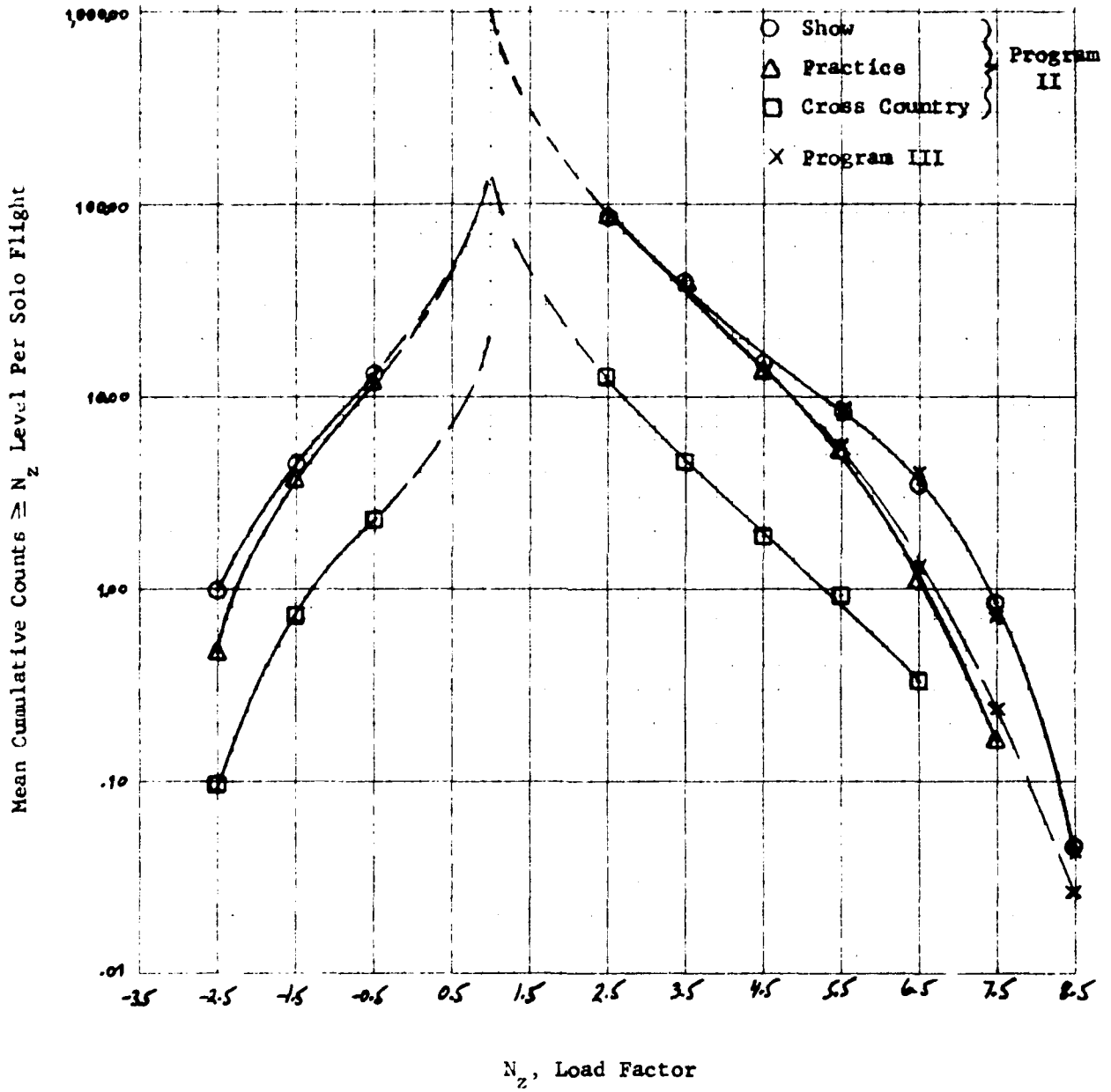

Figure 3. Load Exceedance Curves for Mean N_z Counts

DEFINITION OF A BLUE ANGELS SOLO AIRPLANE SHOW/PRACTICE/CROSS COUNTRY FLIGHT

The show flight profile for the solo airplane, as provided by the Navy Flight Demonstration Team, is as follows:

Blue Angel Solo Airplane Show Flight Profile

Solo Aircraft	Opposing Solo Aircraft
1. Gear down - Full flaps - 360° horizontal take-off roll	1. Gear down - Flaps up-360° horizontal take-off roll
2. Six vertical climbing rolls	2. Same as solo aircraft
3. Knife edge pass	3. "
4. Inverted pass	4. "
5. Four point horizontal roll	5. "
6. Three horizontal rolls	6. "
7. One-half of a Cuban eight maneuver	7. "
8. Eight point horizontal roll	8. Inverted-to-inverted slow roll
9. Joins Delta*	9. Same as solo aircraft
a. Delta roll	a. "
b. Delta loop	b. "
c. Loop break (Includes ½ Cuban eight)	c. "
d. Six plane cross	d. "
10. Spacer maneuver	10. "
11. Dirty loop**	11. No maneuver
12. Tuck away break	12. Same as solo aircraft
13. Simulated carrier landing	13. "

* Monitoring program I did not include Delta maneuvers. Therefore the following substitutions will be made:

For	Use
Delta roll	Take-off roll
Delta loop	Blivot maneuver
Loop break	One-half Cuban eight
Six plane cross	Head-on maneuver

** Monitoring program I did not include a Dirty loop. Therefore a Blivot maneuver will be substituted for the Dirty loop.

In keeping with the solo aircraft show flight profile shown on page 23 the following maneuvers, in sequence, will constitute a show flight:

Solo Show Flight

Maneuver*	Assumed frequency of occurrence per flight
1. TOR	1
2. 6CR	1
3. KE (1)	.8
KE (2)	.2
4. IVD	1
5. 4PR	1
6. 3HR (1)	.8
3HR (2)	.2
7. ½ C8 (1)	.75
½ C8 (2)	.2
½ C8 (3)	.05
8. 8PR	1
9. TOR	1
10. BLV	1
11. ½ C8 (1)	1
12. HO	1
13. SP	1
14. BLV	1
15. TAB (1)	.4
TAB (2)	.4
TAB (3)	.2
16. LDG	1

In order to correlate with measured flight data, the BML maneuver (4 counts of N_z = 2.5) is required between each of the above numbered maneuvers.

* Abbreviations and maneuvers are as defined in the section of this report entitled "Definition of Maneuvers."

Using the peak count maneuver definitions given in the section of this report entitled "Definition of Maneuvers", a solo show flight in terms of N_z counts can be constructed and compared to the measured show data (see Table IV and Figure 4) as follows:

Solo Show Flight Profile

Constructed Using Average Peak N_z Counts

Show Maneuvers

N_z	TOR	6CR	KE	IVD	4PR	3HR	½C8	8PR	TOR	BLV	½C8	HO	SP	BLV	TAB	LDG	BML
8.5							.05										
7.5			.2			.2	.2								.2		
6.5							1				1		1				
5.5		1	.8	1	1										.8		
4.5					1	1.8	.75	1		1	1			1	1		
3.5	1	2	1	1	1	1	1	1	1	3	1	2		3			
2.5	1		1						1								60
-0.5		1				2	2			1	2			1	.6		
-1.5			1		1			1							.4		
-2.5				1													
1.37																1	

	Total Discrete N_z Counts	Total Cumulative N_z Counts
8.5	.05	.05
7.5	.80	.85
6.5	3.00	3.85
5.5	4.60	8.45
4.5	8.55	17.00
3.5	19.00	36.00
2.5	63.00	99.00
-0.5	9.60	14.00
-1.5	3.40	4.40
-2.5	1.00	1.00

Table IV

Cumulative Peak N_z Counts to Equal or Exceed
A Set N_z Level for a Solo Show Flight

N_z	Monitoring Method I (Constructed)	Monitoring Method II ($\bar{X}$)	Monitoring Method III ($\bar{X}$)
8.5	.05	.045	.041
7.5	.85	.847	.757
6.5	3.85	3.685	4.003
5.5	8.45	8.128	8.822
4.5	17.00	16.565	-
3.5	36.00	41.226	-
2.5	99.00	86.194	-
-0.5	14.00	13.923	-
-1.5	4.40	4.409	-
-2.5	1.00	.99	-

Note: $\bar{X}$ = Mean values as determined by a regression analysis of measured data (See the section of this report entitled "Determination of the Load Exceedance Curves").

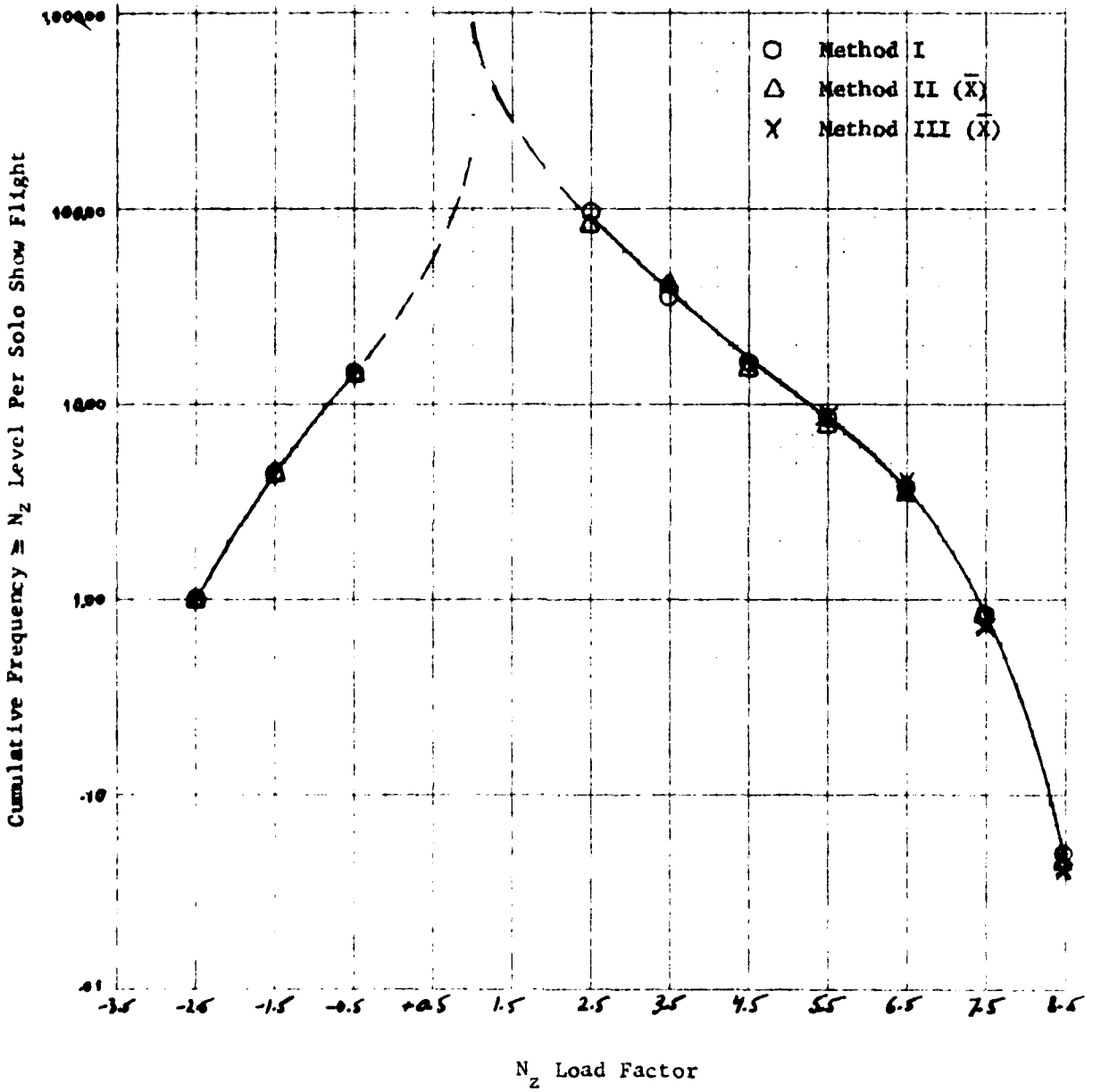

Figure 4. Solo Show Flight Profile.

In defining the practice flight profile it was determined that a practice flight is similar to a show flight, but that identical maneuvers are not necessarily performed. In order to allow for a correlation with measured flight, a practice flight profile was constructed. The following maneuvers, in sequence, will constitute a practice flight.

Solo Practice Flight

Maneuver	Assumed Frequency of Occurrence per flight
1. TOR	1
2. 6CR	1
3. KE (1)	1
4. I	.5
KE (1)	.5
5. 4PR	1
6. 3HR (1)	1
7. ½C8 (1)	.975
½C8 (3)	.025
8. 8PR	1
9. HO	1
10. BLV	1
11. 3HR (1)	1
12. HO	1
13. TAB (1)	.8
TAB (3)	.2
14. LDG	1

As with the show flight, the BML maneuver (4 counts of $N_z = 2.5$) will occur between each of the above numbered maneuvers.

Using the peak count maneuver definitions, a solo practice flight can be constructed and compared to the measured practice data (see Table V and Figure 5) as follows:

Solo Practice Flight Profile

Constructed Using Average Peak N_z Counts

Practice Maneuvers

N_z	TOR	6CR	KE	IVD	KE	4PR	3HR	½C8	8PR	HO	BLV	3HR	HO	TAB	LDG	BML
8.5								.025								
7.5														.2		
6.5								1								
5.5		1	1	.5	.5	1								.8		
4.5						1	2	.975	1		1	2		1		
3.5	1	2	1	.5	.5	1	1	1	1	2	3	1	2			
2.5	1		1		.5											52
-0.5		1					2	2			1	2		1		
-1.5			1		.5	1			1							
-2.5				.5												
1.37															1	

	Total Discrete N_z Counts	Total Cumulative N_z Counts
8.5	.025	.025
7.5	.2	.225
6.5	1.0	1.225
5.5	4.8	6.025
4.5	8.975	15.00
3.5	17.0	32.00
2.5	54.5	86.50
-0.5	9.0	13.0
-1.5	3.5	4.0
-2.5	.5	.5

Table V

Cumulative Peak N_z Counts to Equal or Exceed A Set N_z Level for a Solo Practice Flight

N_z	Monitoring Method I (Constructed)	Monitoring Method II ($\bar{X}$)	Monitoring Method III ($\bar{X}$)
8.5	.025	0	.027
7.5	.225	.177	.257
6.5	1.225	1.166	1.334
5.5	6.025	5.313	5.939
4.5	15.0	15.440	-
3.5	32.0	39.779	-
2.5	86.5	89.605	-
-0.5	13.0	12.605	-
-1.5	4.0	3.803	-
-2.5	.5	.473	-

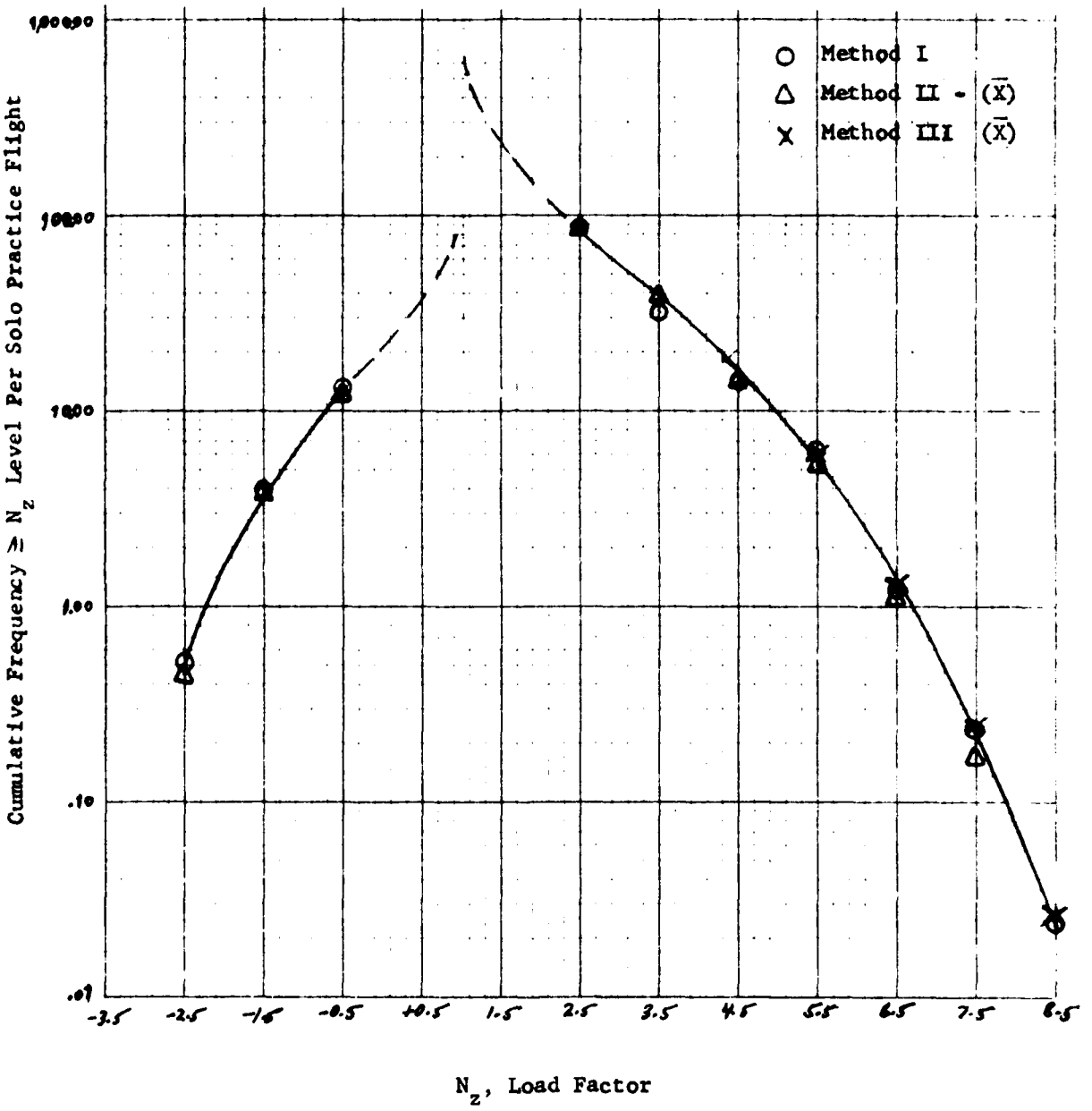

Figure 5. Solo Practice Flight Profile.

In order to define a cross-country flight profile that would correlate with measured data, it was assumed that no load levels above 1.74G or below 0.26G are experienced during the actual cross-country run. However, it is assumed that at least two show maneuvers are performed at the conclusion of the cross-country run. The following maneuvers, in sequence, will constitute the cross-country flight:

Solo Cross-Country Flight

Maneuver		Assumed Frequency of Occurrence per flight
1.	3HR (1)	.475
	3HR (2)	.025
	6CR	.5
2.	SP	.3
	8PR	.6
	IVD	.1
3.	LDG	1.0

Between each numbered maneuver the BML maneuver (4 counts of N_z = 2.5) will occur.

Using the peak count maneuver definitions, a solo cross-country flight can be constructed and compared to measured cross-country data (see Table VI and Figure 6) as follows:

Solo Cross-Country Flight Profile

Constructed Using Average Peak N_z Counts

	Cross-Country Maneuvers							Total	
N_z	3HR	6CR	SP	8PR	IVD	LDG	BML	Discrete N_z Counts	Cumulative N_z Counts
8.5								0	0
7.5	.025							.025	.025
6.5			.3					.300	.325
5.5		.5			.1			.600	.925
4.5	.975			.6				1.575	2.500
3.5	.5	1		.6	.1			2.200	4.700
2.5							8	8.000	12.700
-0.5	1	.5						1.500	2.200
-1.5				.6				.600	.700
-2.5					.1			.100	.100
1.37						1			

Table VI

Cumulative Peak N_z Counts to Equal or Exceed
A Set N_z Level for a Solo Cross-Country Flight

N_z	Monitoring Method I (Constructed)	Monitoring Method II ($\bar{X}$)	Monitoring Method III ($\bar{X}$)
8.5	0	0	
7.5	.025	.011	
6.5	.325	.338	
5.5	.925	.909	
4.5	2.500	1.930	Not Calculated
3.5	4.700	4.731	
2.5	12.700	13.679	
-0.5	2.200	2.354	
-1.5	.700	.726	
-2.5	.100	.097	

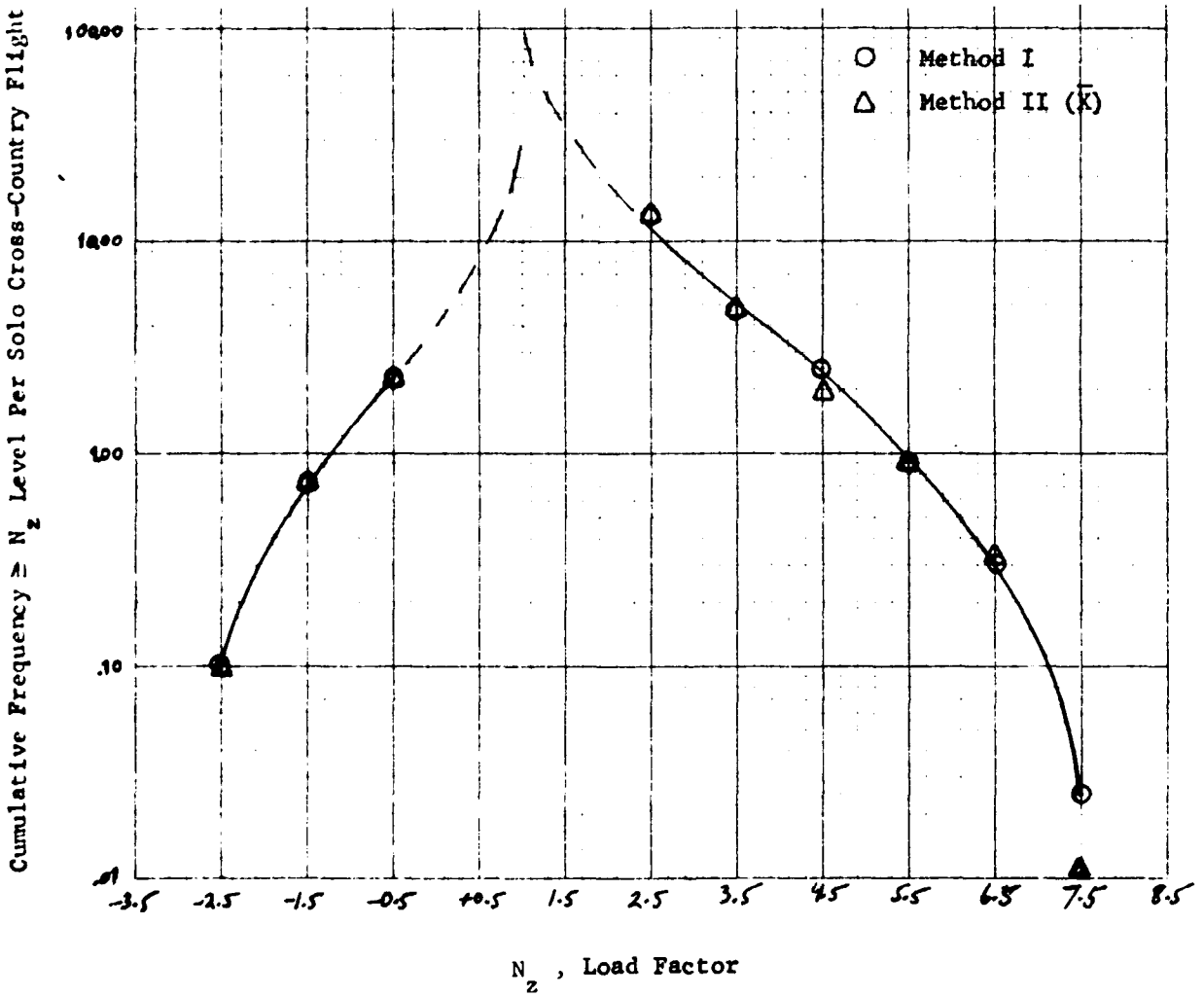

Figure 6. Solo Cross-Country Flight Profile.

DETERMINATION OF BLUE ANGELS FLIGHT TYPE UTILIZATION MIX

The determination of the flight type utilization mix is based primarily on information provided by monitoring method III (the counting accelerometer program). Monitoring method III data for the period May 1974 to April 1975 indicates the following:

Flight Category	Average Percent of Flight Hours Spent in Flight Category
Show (S)	12.9%
Practice (P)	45.0%
Cross-Country & Other (C)	42.1%

The statistical analysis of monitoring method III data, as reported in the section of this report entitled "Determination of the Load Exceedance Curves", provided the following:

Average Show Flight	=	0.837 Log Book Flight Hours
Average Practice Flight	=	1.131 " " " "
Average Cross-Country Flight	=	1.359 " " " "

The Blue Angels schedule calls for a show season of approximately 70 show flights over a 36-week period and a practice season (during which no shows are flown) of 16 weeks. Therefore, using the above information, a utilization mix for a one-year time period can be determined as follows:

(1) 70 show flts/yr x .0837 hrs/show flt = 58.59 show flt hrs/yr

(2) 58.59 show flt hrs/yr ÷ 0.129 show flt hrs/total flt hrs = 454.186 total flt hrs/yr

(3) 454.186 total flt hrs/yr x 0.45 practice flt hrs/total flt hrs = 204.384 practice flt hrs/yr

(4) 204.384 practice flt hrs/yr ÷ 1.131 hrs/practice flt = 180.711 practice flts/yr

(5) 454.186 total flt hrs/yr x 0.421 cross-country flt hrs/total flt hrs = 191.212 cross country flt hrs/yr

(6) 191.202 cross-country flt hrs/yr ÷ 1.359 hrs/cross country flt = 140.701 cross-country flts/yr

Therefore, for a one-year time period, which includes a show season and a practice season, the following utilization mix is determined.

Flt Category	Flts	Flt Hrs	% of Total Flt Hrs	% of Total Flts
S	70	58.6	13.0	17.9
P	180	203.6	45.0	46.2
C	140	190.3	42.0	35.9
	390	452.5		

Based on current usage, a show season covers 35 weeks and typically includes 70 shows, 70 practice flights, and 70 cross-country flights. The practice season covers 17 weeks and would include zero shows, 110 practice flights and 70 cross-country flights.

A utilization spectrum for one year's operations is assumed as follows:

Week		
1	C → P → S → S → C → P (Repeat 35 times)	Show Season
36	C → 4P → C → C → 3P → C (Repeat 15 times)	Practice Season
51	C → C → 3P → C → C → 2P → C → C	
52	C → C → C → C	

DEVELOPMENT OF THE TEST SPECTRUM

An examination of the definition of a Blue Angels solo airplane show/practice/cross-country flight, as given in the section of this report entitled "Definition of a Blue Angels Solo Airplane Show/Practice/Cross-Country Flight", reveals that there are actually four different show flight profiles, five different practice flight profiles, and six different cross-country flight profiles. These profiles are described in Tables VII, VIII and IX. It is further found that the four show flights produce a spectrum that repeats after 20 show flights have been completed, the five practice flights, and similarly the six cross-country flights, produce spectra that repeat after 40 Practice/cross-country flights have been completed. These separate repeatable spectra for each type of flight are shown in Table X. Combining the foregoing with the utilization mix and spectrum given in the section of this report entitled "Determination of Blue Angels Flight Type Utilization Mix", produces a total test spectrum that repeats after 2 years of operations. This total test spectrum is given in Table XI.

Table VII

Test Spectrum Show Flight Profiles

Maneuver	Flight Code / Times Repeated in 20 Show Flights	S1 (8)	S2 (7)	S3 (4)	S4 (1)	Total Counts of Maneuver in 20 Show Flights
1. TOR		X	X	X	X	20
2. 6CR		X	X	X	X	20
3. KE(1)		X	X	-	X	16
KE(2)		-	-	X	-	4
4. IVD		X	X	X	X	20
5. 4PR		X	X	X	X	20
6. 3HR(1)		X	X	-	X	16
3HR(2)		-	-	X	-	4
7. ½C8(1)		X	X	-	-	15
½C8(2)		-	-	X	-	4
½C8(3)		-	-	-	X	1
8. 8PR		X	X	X	X	20
9. TOR		X	X	X	X	20
10. BLV		X	X	X	X	20
11. ½C8(1)		X	X	X	X	20
12. HO		X	X	X	X	20
13. SP		X	X	X	X	20
14. BLV		X	X	X	X	20
15. TAB(1)		X	-	-	-	8
TAB(2)		-	X	-	X	8
TAB(3)		-	-	X	-	4
16. LDG		X	X	X	X	20

Note: Between maneuver loading (BML) will be the same for all flights and will consist of 4 counts of $N_z = 2.5$ applied after the conclusion of every maneuver except Landing.

Table VIII

Test Spectrum Practice Flight Profiles

Maneuver	Flight Code / Times Repeated in 40 Pract. Flts.	P1 (16)	P2 (16)	P3 (4)	P4 (3)	P5 (1)	Total counts of Maneuver in 40 Practice Flights
1. TOR		X	X	X	X	X	40
2. 6CR		X	X	X	X	X	40
3. KE(1)		X	X	X	X	X	40
4. IVD		X	-	X	-	-	20
KE(1)		-	X	-	X	X	20
5. 4PR		X	X	X	X	X	40
6. 3HR(1)		X	X	X	X	X	40
7. ½C8(1)		X	X	X	X	-	39
½C8(3)		-	-	-	-	X	1
8. 8PR		X	X	X	X	X	40
9. HO		X	X	X	X	X	40
10. BLV		X	X	X	X	X	40
11. 3HR(1)		X	X	X	X	X	40
12. HO		X	X	X	X	X	40
13. TAB(1)		X	X	-	-	-	32
TAB(3)		-	-	X	X	X	8
14. LDG		X	X	X	X	X	40

Note: Between maneuver loading (BML) will be the same for all flights and will consist of 4 counts of N_z = 2.5 applied after the conclusion of every maneuver except Landing.

Table IX

Test Spectrum Cross-Country Flight Profiles

Maneuver	Flight Code / Times Repeated in 40 Cross-Cty Flts.	C1 (12)	C2 (12)	C3 (7)	C4 (4)	C5 (4)	C6 (1)	Total Counts of Maneuver in 40 Cross-Cty. Flts.
1.	3HR(1)	X	-	X	-	-	-	19
	3HR(2)	-	-	-	-	-	X	1
	6CR	-	X	-	X	X	-	20
2.	8PR	X	X	-	-	-	-	24
	SP	-	-	X	X	-	X	12
	IVD	-	-	-	-	X	-	4
3.	LDG	X	X	X	X	X	X	40

Note: Between maneuver loading (BML) will be the same for all flights and will consist of 4 counts of $N_z = 2.5$ applied after the conclusion of every maneuver except Landing.

Table X

Show/Practice/Cross-Country Flight Spectra

Show Flt Spectrum		Practice Flight Spectrum				Cross-Country Flight Spectrum			
Seq Show Flts	Flt Code	Seq Pr Flts	Flt Code	Seq Pr Flts	Flt Code	Seq Cr Cty Flts	Flt Code	Seq Cr Cty Flts	Flt Code
1	S1	1	P1	21	P1	1	C1	21	C1
2	S2	2	P2	22	P2	2	C2	22	C2
3	S1	3	P1	23	P1	3	C3	23	C3
4	S2	4	P2	24	P2	4	C2	24	C2
5	S3	5	P3	25	P3	5	C1	25	C1
6	S1	6	P2	26	P2	6	C4	26	C4
7	S2	7	P1	27	P1	7	C1	27	C1
8	S1	8	P2	28	P2	8	C2	28	C2
9	S2	9	P1	29	P1	9	C3	29	C3
10	S3	10	P4	30	P4	10	C5	30	C5
11	S1	11	P1	31	P1	11	C1	31	C1
12	S2	12	P2	32	P2	12	C2	32	C2
13	S1	13	P1	33	P1	13	C3	33	C3
14	S2	14	P2	34	P2	14	C2	34	C2
15	S3	15	P3	35	P3	15	C1	35	C1
16	S1	16	P2	36	P2	16	C4	36	C4
17	S2	17	P1	37	P1	17	C1	37	C1
18	S1	18	P2	38	P2	18	C2	38	C2
19	S4	19	P1	39	P1	19	C3	39	C6
20	S3	20	P4	40	P5	20	C5	40	C5
Repeat every 20 show flts.		Repeat every 40 practice flts.				Repeat every 40 cross-country flts.			

Note: **Seq** = **Sequential**
PR = **Practice**
CrCty = **Cross Country**

TABLE XI

Total Test Spectrum

YEAR 1
FLIGHT 1 - 210

FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE
1	C1	36	P2	71	C2	106	S1	141	S2	176	P1
2	P1	37	C3	72	P2	107	C4	142	S1	177	S4
3	S1	38	P1	73	C1	108	P2	143	C2	178	S3
4	S2	39	S1	74	P3	109	C1	144	P2	179	C5
5	C2	40	S2	75	S3	110	P1	145	C3	180	P4
6	P2	41	C2	76	S1	111	S2	146	P1	181	C1
7	C3	42	P2	77	C4	112	S1	147	S2	182	P1
8	P1	43	C1	78	P2	113	C2	148	S3	183	S1
9	S1	44	P3	79	C1	114	P2	149	C5	184	S2
10	S2	45	S3	80	P1	115	C6	150	P4	185	C2
11	C2	46	S1	81	S2	116	P1	151	C1	186	P2
12	P2	47	C4	82	S1	117	S4	152	P1	187	C3
13	C1	48	P2	83	C2	118	S3	153	S1	188	P1
14	P3	49	C1	84	P2	119	C5	154	S2	189	S1
15	S3	50	P1	85	C3	120	P5	155	C2	190	S2
16	S1	51	S2	86	P1	121	C1	156	P2	191	C2
17	C4	52	S1	87	S2	122	P1	157	C3	192	P2
18	P2	53	C2	88	S3	123	S1	158	P1	193	C1
19	C1	54	P2	89	C5	124	S2	159	S1	194	P3
20	P1	55	C3	90	P4	125	C2	160	S2	195	S3
21	S2	56	P1	91	C1	126	P2	161	C2	196	S1
22	S1	57	S4	92	P1	127	C3	162	P2	197	C4
23	C2	58	S3	93	S1	128	P1	163	C1	198	P2
24	P2	59	C5	94	S2	129	S1	164	P3	199	C1
25	C3	60	P4	95	C2	130	S2	165	S3	200	P1
26	P1	61	C1	96	P2	131	C2	166	S1	201	S2
27	S2	62	P1	97	C3	132	P2	167	C4	202	S1
28	S3	63	S1	98	P1	133	C1	168	P2	203	C2
29	C5	64	S2	99	S1	134	P3	169	C1	204	P2
30	P4	65	C2	100	S2	135	S3	170	P1	205	C3
31	C1	66	P2	101	C2	136	S1	171	S2	206	P1
32	P1	67	C3	102	P2	137	C4	172	S1	207	S2
33	S1	68	P1	103	C1	138	P2	173	C2	208	S3
34	S2	69	S1	104	P3	139	C1	174	P2	209	C5
35	C2	70	S2	105	S3	140	P1	175	C3	210	P4

TABLE XI (Cont'd)

Total Test Spectrum

YEAR 1

FLIGHTS 211 - 390

FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE
211	C1	242	P1	273	P4	304	C2	335	P4	366	P1
212	P1	243	C2	274	P1	305	C1	336	P1	367	P4
213	P2	244	C3	275	P2	306	P1	337	C4	368	P1
214	P1	245	P2	276	C2	307	P2	338	C1	369	P2
215	P2	246	P1	277	C1	308	P1	339	P2	370	C2
216	C2	247	P2	278	P1	309	C4	340	P1	371	C3
217	C3	248	P3	279	P2	310	C1	341	P2	372	P1
218	P3	249	C2	280	P3	311	P2	342	C2	373	P2
219	P2	250	C1	281	P2	312	P3	343	C6	374	P3
220	P1	251	P2	282	C4	313	P2	344	P3	375	C5
221	C2	252	P1	283	C1	314	P1	345	P2	376	C1
222	C1	253	P2	284	P1	315	C2	346	P1	377	C2
223	P2	254	C4	285	P2	316	C3	347	P2	378	P2
224	P1	255	C1	286	P1	317	P2	348	C5	379	P1
225	P5	256	P1	287	C2	318	P1	349	C1	380	P2
226	P1	257	P4	288	C3	319	P4	350	P1	381	C3
227	C4	258	P1	289	P5	320	C5	351	P5	382	C2
228	C1	259	P2	290	P1	321	C1	352	P1	383	P1
229	P2	260	C2	291	P2	322	P1	353	C2	384	P4
230	P1	261	C3	292	P1	323	P2	354	C3	385	C1
231	P2	262	P1	293	C5	324	P1	355	P2	386	C4
232	C2	263	P2	294	C1	325	P2	356	P1	387	C1
233	C6	264	P3	295	P2	326	C2	357	P2	388	C2
234	P3	265	C5	296	P3	327	C3	358	P3	389	C3
235	P2	266	C1	297	P2	328	P3	359	C2	390	C5
236	P1	267	P2	298	C2	329	P2	360	C1		
237	P2	268	P1	299	C3	330	P1	361	P2		
238	C5	269	P2	300	P1	331	C2	362	P1		
239	C1	270	P1	301	P2	332	C1	363	P2		
240	P1	271	C2	302	P1	333	P2	364	C4		
241	P4	272	C3	303	P4	334	P1	365	C1		

TABLE XI (Cont'd)

Total Test Spectrum

YEAR 2

FLIGHTS 1 - 210

FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE
1	C1	36	P2	71	C2	106	S1	141	S2	176	P1
2	P1	37	C3	72	P2	107	C4	142	S1	177	S4
3	S1	38	P1	73	C1	108	P2	143	C2	178	S3
4	S2	39	S1	74	P3	109	C1	144	P2	179	C5
5	C2	40	S2	75	S3	110	P1	145	C3	180	P5
6	P2	41	C2	76	S1	111	S2	146	P1	181	C1
7	C3	42	P2	77	C4	112	S1	147	S2	182	P1
8	P1	43	C1	78	P2	113	C2	148	S3	183	S1
9	S1	44	P3	79	C1	114	P2	149	C5	184	S2
10	S2	45	S3	80	P1	115	C3	150	P4	185	C2
11	C2	46	S1	81	S2	116	P1	151	C1	186	P2
12	P2	47	C4	82	S1	117	S4	152	P1	187	C3
13	C1	48	P2	83	C2	118	S3	153	S1	188	P1
14	P3	49	C1	84	P2	119	C5	154	S2	189	S1
15	S3	50	P1	85	C3	120	P4	155	C2	190	S2
16	S1	51	S2	86	P1	121	C1	156	P2	191	C2
17	C4	52	S1	87	C2	122	P1	157	C3	192	P2
18	P2	53	C2	88	S3	123	S1	158	P1	193	C1
19	C1	54	P2	89	C5	124	S2	159	S1	194	P3
20	P1	55	C6	90	P4	125	C2	160	S2	195	S3
21	S2	56	P1	91	C1	126	P2	161	C2	196	S1
22	S1	57	S4	92	P1	127	C3	162	P2	197	C4
23	C2	58	S3	93	S1	128	P1	163	C1	198	P2
24	P2	59	C5	94	S2	129	S1	164	P3	199	C1
25	C3	60	P5	95	C2	130	S2	165	S3	200	P1
26	P1	61	C1	96	P2	131	C2	166	S1	201	S2
27	S2	62	P1	97	C3	132	P2	167	C4	202	S1
28	S3	63	S1	98	P1	133	C1	168	P2	203	C2
29	C5	64	S2	99	S1	134	P3	169	C1	204	P2
30	P4	65	C2	100	S2	135	S3	170	P1	205	C3
31	C1	66	P2	101	C2	136	S1	171	S2	206	P1
32	P1	67	C3	102	P2	137	C4	172	S1	207	S2
33	S1	68	P1	103	C1	138	P2	173	C2	208	S3
34	S2	69	S1	104	P3	139	C1	174	P2	209	C5
35	C2	70	S2	105	S3	140	P1	175	C6	210	P4

TABLE XI (Cont'd)

Total Test Spectrum

YEAR 2

FLIGHTS 211 - 390

FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE	FLT NO.	FLT TYPE
211	C1	242	P1	273	P4	304	C2	335	P4	366	P1
212	P1	243	C2	274	P1	305	C1	336	P1	367	P4
213	P2	244	C3	275	P2	306	P1	337	C4	368	P1
214	P1	245	P2	276	C2	307	P2	338	C1	369	P2
215	P2	246	P1	277	C1	308	P1	339	P2	370	C2
216	C2	247	P2	278	P1	309	C4	340	P1	371	C3
217	C3	248	P3	279	P2	310	C1	341	P2	372	P1
218	P3	249	C2	280	P3	311	P2	342	C2	373	P2
219	P2	250	C1	281	P2	312	P3	343	C3	374	P3
220	P1	251	P2	282	C4	313	P2	344	P3	375	C5
221	C2	252	P1	283	C1	314	P1	345	P2	376	C1
222	C1	253	P2	284	P1	315	C2	346	P1	377	C2
223	P2	254	C4	285	P2	316	C3	347	P2	378	P2
224	P1	255	C1	286	P1	317	P2	348	C5	379	P1
225	P4	256	P1	287	C2	318	P1	349	C1	380	P2
226	P1	257	P5	288	C6	319	P5	350	P1	381	C3
227	C4	258	P1	289	P4	320	C5	351	P4	382	C2
228	C1	259	P2	290	P1	321	C1	352	P1	383	P1
229	P2	260	C2	291	P2	322	P1	353	C2	384	P5
230	P1	261	C3	292	P1	323	P2	354	C3	385	C1
231	P2	262	P1	293	C5	324	P1	355	P2	386	C4
232	C2	263	P2	294	C1	325	P2	356	P1	387	C1
233	C3	264	P3	295	P2	326	C2	357	P2	388	C2
234	P3	265	C5	296	P3	327	C3	358	P3	389	C6
235	P2	266	C1	297	P2	328	P3	359	C2	390	C5
236	P1	267	P2	298	C2	329	P2	360	C1		
237	P2	268	P1	299	C3	330	P1	361	P2		
238	C5	269	P2	300	P1	331	C2	362	P1		
239	C1	270	P1	301	P2	332	C1	363	P2		
240	P1	271	C2	302	P1	333	P2	364	C4		
241	P4	272	C3	303	P4	334	P1	365	C1		

Note: The spectrum repeats year 1 and year 2 continuously.

FREQUENCY OF LOAD COUNTS PER 1,000 FLIGHT HOURS

The cumulative frequencies of occurrence of loads to equal or exceed a set N_z load level per 1,000 flight hours is presented in Table XII and plotted on Figure 7. It is assumed that the airplane in question always remains a solo position airplane. The frequency of occurrence for the combined spectrum is determined by using a utilization mix as follows: 13% of total flight hours is shows, 45% is practice, and 42% is cross-country. All data used in determining the frequencies are statistical means.

TABLE XII

Cumulative Frequency of Occurrence to Equal or Exceed N_z Level Per 1,000 Flight Hours

	Test Spectrum				Oscillograph Data (Through Nov,1974)			
N_z	Show	Practice	Cross Country	Combined	Show	Practice	Cross Country	Combined
8.5	60	22	0	18	54	0	0	7
7.5	1,016	199	18	229	1,012	156	8	205
6.5	4,600	1,083	239	1,186	4,403	1,031	249	1,141
5.5	10,096	5,327	681	3,996	9,711	4,698	669	3,658
4.5	20,311	13,263	1,840	9,382	19,791	13,652	1,420	9,313
3.5	43,011	28,294	3,458	19,776	49,255	35,172	3,481	23,693
2.5	118,280	76,481	9,345	53,718	102,980	79,226	10,065	53,266
-0.5	16,726	11,494	1,619	8,027	16,634	11,145	1,732	7,905
-1.5	5,257	3,537	515	2,491	5,268	3,363	534	2,422
-2.5	1,195	442	74	385	1,183	418	71	372

Counting Accel. Data (Through Dec, 1974)

N_z	Show	Practice
8.5	49	24
7.5	904	228
6.5	4,783	1,180
5.5	10,540	5,251
4.5	-	-
3.5	-	-
2.5	-	-
-0.5	-	-
-1.5	-	-
-2.5	-	-

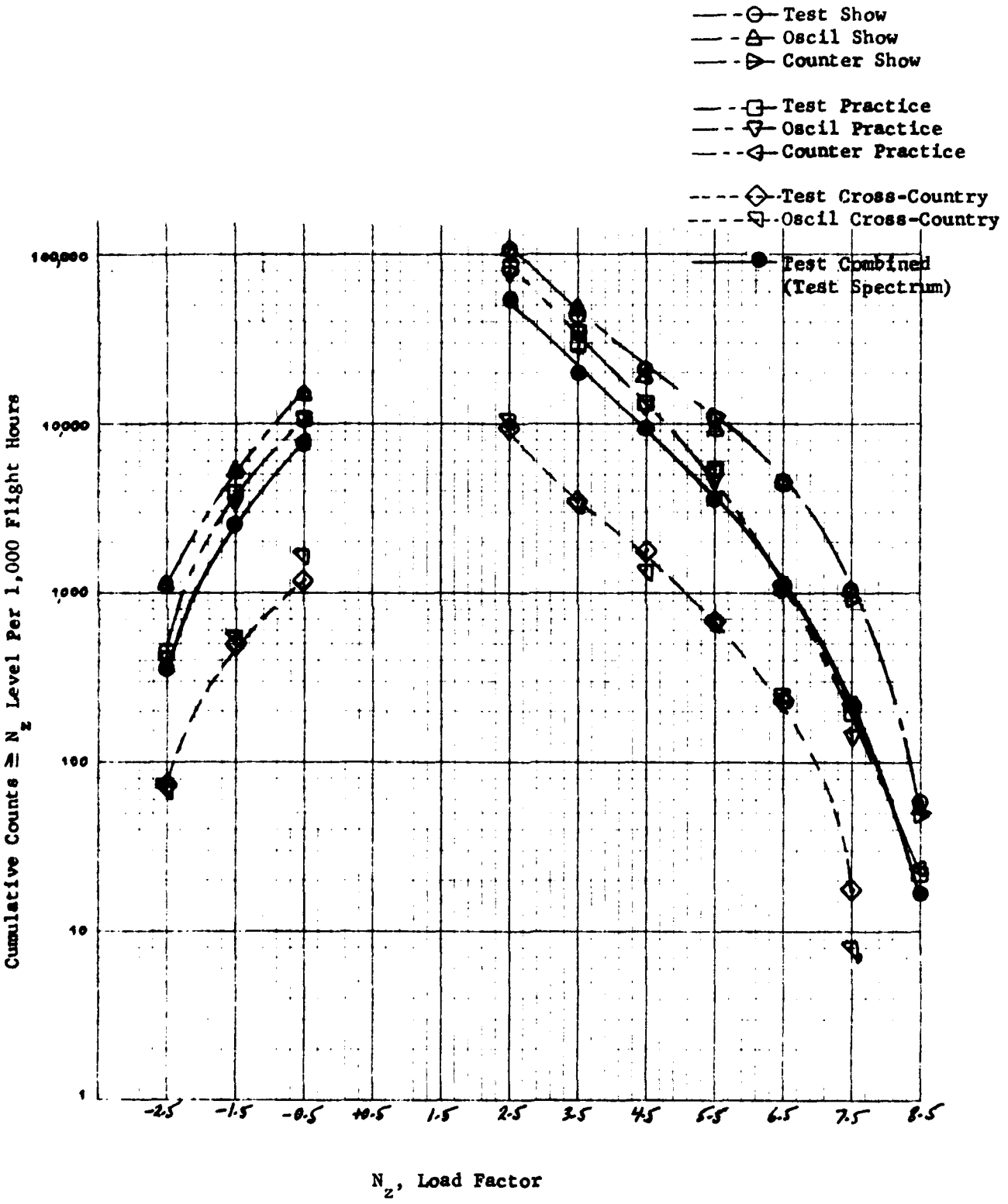

Figure 7. Frequencies Per 1,000 Flight Hours

DETAILED EXAMPLE OF A SINGLE FLIGHT LOADING SPECTRUM

The load levels and sequence of load level application (e.g. the loading spectrum) for flight 16 of Year 2 is detailed as follows:

Flight 16, Year 2

1. From Table XI it is found that Flight 16 of Year 2 is an S1 type of flight. That is, it is a show flight having a flight profile identified as S1.

2. From Table VII it is found that an S1 flight profile is composed of the following maneuvers in sequence:

1.	TOR	9.	TOR
	BML		BML
2.	6CR	10.	BLV
	BML		BML
3.	KE (1)	11.	½C8 (1)
	BML		BML
4.	IVD	12.	HO
	BML		BML
5.	4PR	13.	SP
	BML		BML
6.	3HR (1)	14.	BLV
	BML		BML
7.	½C8 (1)	15.	TAB (1)
	BML		BML
8.	8PR	16.	LDG
	BML		

3. The maneuver definitions are found in Table I. Inserting the N_z and $\dot{\omega}_x$ values for the maneuvers, the actual test loading and sequence is determined as follows:

Sequential Loading for Flight 16, Year 2

1.	1.0	37.	2.5	73.	-1.5	109.	4.5	145.	⑥4.5	181.	-0.5				
2.	⑦2.5	38.	1.0	74.	-1.5-12	110.	0	146.	4.5-12	182.	0				
3.	1.0	39.	③3.5	75.	-1.5	111.	-1.5	147.	4.5	183.	1.5				
4.	3.5	40.	3.5-12	76.	-1.5+12	112.	-1.5-12	148.	0	184.	1.5-12				
5.	1.0	41.	3.5	77.	-1.5	113.	-1.5	149.	-0.5	185.	1.5				
6.	2.5	42.	3.5+12	78.	-2.5	114.	-1.5+12	150.	0	186.	0				
7.	1.0	43.	3.5	79.	-1.5	115.	-1.5	151.	1.0	187.	-0.5				
8.	2.5	44.	0	80.	-1.5-12	116.	-1.5-12	152.	0	188.	0				
9.	1.0	45.	-1.5	81.	-1.5	117.	-1.5	153.	-0.5	189.	3.5				
10.	2.5	46.	0	82.	-1.5+12	118.	-1.5+12	154.	0	190.	3.5+12				
11.	1.0	47.	1.5	83.	-1.5	119.	-1.5	155.	3.5	191.	3.5				
12.	2.5	48.	1.5-12	84.	0	120.	0	156.	3.5+12	192.	4.5				
13.	1.0	49.	1.5	85.	3.5	121.	3.5	157.	3.5	193.	1.5				
14.	⑤5.5	50.	1.5+12	86.	1.5	122.	3.5-12	158.	1.0	194.	1.5-12				
15.	3.5	51.	1.5	87.	1.5-12	123.	3.5	159.	3.5	195.	1.5				
16.	3.5-12	52.	2.5	88.	1.5	124.	3.5+12	160.	3.5-12	196.	1.5+12				
17.	3.5	53.	1.5	89.	1.5+12	125.	3.5	161.	3.5	197.	1.5				
18.	0	54.	1.5-12	90.	1.5	126.	1.0	162.	3.5+12	198.	6.5				
19.	-0.5	55.	1.5	91.	5.5	127.	5.5	163.	3.5	199.	5.5				
20.	0	56.	1.5+12	92.	5.5-6	128.	5.5-6	164.	4.5	200.	5.5-6				
21.	3.5	57.	1.5	93.	5.5	129.	5.5	165.	1.0	201.	5.5				
22.	3.5+12	58.	5.5	94.	5.5+6	130.	5.5+6	166.	2.5	202.	5.5+6				
23.	3.5	59.	5.5-6	95.	5.5	131.	5.5	167.	1.0	203.	5.5				
24.	1.5	60.	5.5	96.	1.0	132.	5.5-6	168.	2.5	204.	1.0				
25.	1.5-6	61.	5.5+6	97.	2.5	133.	5.5	169.	1.0	205.	2.5				
26.	1.5	62.	5.5	98.	1.0	134.	5.5+6	170.	2.5	206.	1.0				
27.	1.5+6	63.	1.0	99.	2.5	135.	5.5	171.	1.0	207.	2.5				
28.	1.5	64.	2.5	100.	1.0	136.	1.0	172.	2.5	208.	1.0				
29.	3.5	65.	1.0	101.	2.5	137.	2.5	173.	1.0	209.	2.5				
30.	1.0	66.	2.5	102.	1.0	138.	1.0	174.	⑦3.5	210.	1.0				
31.	2.5	67.	1.0	103.	2.5	139.	2.5	175.	1.5	211.	2.5				
32.	1.0	68.	2.5	104.	1.0	140.	1.0	176.	1.5-6	212.	1.0				
33.	2.5	69.	1.0	105.	④4.5	141.	2.5	177.	1.5	213.	⑧4.5				
34.	1.0	70.	2.5	106.	4.5-12	142.	1.0	178.	1.5+6	214.	4.5-12				
35.	2.5	71.	1.0	107.	4.5	143.	2.5	179.	1.5	215.	4.5				
36.	1.0	72.	⑨0	108.	4.5+12	144.	1.0	180.	0	216.	4.5+12				

217.	4.5	253.	2.5	289.	2.5	325.	1.0	361.	5.5+6	397.	1.0
218.	0	254.	1.0	290.	1.0	326.	2.5	362.	5.5	398.	2.5
219.	-1.5	255.	2.5	291.	2.5	327.	1.0	363.	6.5	399.	1.0
220.	-1.5-12	256.	1.0	292.	1.0	328.	2.5	364.	5.5	400.	(17) 4.5
221.	-1.5	257.	2.5	293.	(11) 3.5	329.	1.0	365.	5.5-6	401.	4.5-12
222.	-1.5+12	258.	1.0	294.	1.5	330.	2.5	366.	5.5	402.	4.5
223.	-1.5	259.	(9) 2.5	295.	1.5-6	331.	1.0	367.	5.5+6	403.	4.5+12
224.	-1.5-12	260.	1.0	296.	1.5	332.	(12) 1.5	368.	5.5	404.	4.5
225.	-1.5	261.	3.5	297.	1.5+6	333.	1.5-12	369.	1.0	405.	0
226.	-1.5+12	262.	1.0	298.	1.5	334.	1.5	370.	2.5	406.	-0.5
227.	-1.5	263.	2.5	299.	0	335.	1.5+12	371.	1.0	407.	0
228.	-1.5-12	264.	1.0	300.	-0.5	336.	1.5	372.	2.5	408.	5.5
229.	-1.5	265.	2.5	301.	0	337.	3.5	373.	1.0	409.	1.0
230.	-1.5+12	266.	1.0	302.	1.5	338.	1.5	374.	2.5	410.	2.5
231.	-1.5	267.	2.5	303.	1.5-12	339.	1.5-6	375.	1.0	411.	1.0
232.	-1.5-12	268.	1.0	304.	1.5	340.	1.5	376.	2.5	412.	2.5
233.	-1.5	269.	2.5	305.	0	341.	1.5+6	377.	1.0	413.	1.0
234.	-1.5+12	270.	1.0	306.	-0.5	342.	1.5	378.	(13) 3.5	414.	2.5
235.	-1.5	271.	(10) 3.5	307.	0	343.	3.5	379.	0	415.	1.0
236.	-1.5-12	272.	0	308.	3.5	344.	1.5	380.	-0.5	416.	2.5
237.	-1.5	273.	-0.5	309.	3.5+12	345.	1.5-6	381.	0	417.	1.0
238.	-1.5+12	274.	0	310.	3.5	346.	1.5	382.	3.5	418.	(14) 0
239.	-1.5	275.	3.5	311.	4.5	347.	1.5+6	383.	1.0	419.	1.37
240.	-1.5-12	276.	1.0	312.	1.5	348.	1.5	384.	3.5	420.	0
241.	-1.5	277.	3.5	313.	1.5-12	349.	1.0	385.	1.0	421.	1.0
242.	-1.5+12	278.	1.0	314.	1.5	350.	2.5	386.	4.5		
243.	-1.5	279.	4.5	315.	1.5+12	351.	1.0	387.	4.5-12		
244.	0	280.	4.5-12	316.	1.5	352.	2.5	388.	4.5		
245.	3.5	281.	4.5	317.	6.5	353.	1.0	389.	4.5+12		
246.	3.5-12	282.	4.5+12	318.	5.5	354.	2.5	390.	4.5		
247.	3.5	283.	4.5	319.	5.5-6	355.	1.0	391.	1.0		
248.	3.5+12	284.	1.0	320.	5.5	356.	2.5	392.	2.5		
249.	3.5	285.	2.5	321.	5.5+6	357.	1.0	393.	1.0		
250.	1.0	286.	1.0	322.	5.5	358.	(15) 5.5	394.	2.5		
251.	2.5	287.	2.5	323.	1.0	359.	5.5-6	395.	1.0		
252.	1.0	288.	1.0	324.	2.5	360.	5.5	396.	2.5		

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